

FULGURATION AND THERMO- RADIOTHERAPY

BY

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AND

DIATHERMY (NAGELSCHMIDT) AND ELECTRO-COAGULATION (DOYEN)

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FULGURATION AND THERMO-RADIOTHERAPY.*

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Definition of Terms.

The term "fulguration" (lightning), first applied to the de Keating-Hart method of employing high-frequency discharges of electricity in the treatment of cancer, has come to be employed carelessly in the designation of certain other methods of treating neoplasms, malignant and benign, by means of high-frequency currents.

The term "fulguration" has come to be associated, in the minds of many electro-therapeutists, with the Rivière-Keating-Hart priority controversy which has been waged over the methods advocated respectively by Rivière and de Keating-Hart.

It is not my purpose on this occasion to endeavor to elaborate or to elucidate this controversy. It may not be amiss, however, in the effort to avoid further confusion of terms, to attempt to give a succinct definition of each of the methods to which the term "fulguration" has been applied.

Such an exposition may serve, incidentally, to emphasize the importance of the position which this Association has assumed with reference to a scientific nomenclature in electrotherapy. It is to be hoped that through the efforts of this learned body such confusion of terms will speedily be relegated to the past.

GENERAL CLASSIFICATION OF METHODS.

It may be stated in the beginning that the various methods under discussion are applications of high-frequency currents of electricity. They may be broadly considered as coming within the following classes:

(1) *Cauterization*, or destruction of the growth, with monopolar or bipolar current, and with short spark, of high frequency, high tension and low amperage, often inaccurately called "fulguration," sometimes described as "destructive fulguration," better, perhaps, designated as "high-frequency cauterization."

*Presented, by invitation, with lantern-slide demonstration, before the American Electro-Therapeutic Association, Richmond, Va., September 4, 1912.

(2) *Cauterization*, or destruction of the growth, by using a specially constructed apparatus, with monopolar or bipolar current, with short or long spark, or effleuve, of high frequency, and relatively low tension and high amperage. Rivière's method comes within this class.

(3) *Desiccation*, or the "drying out" of the growth, with a monopolar current, short spark of high frequency and high tension, the action of which is not carried to cauterization, but of rapidly dehydrating the neoplasm and converting it into an inert mass. This is Clark's method.

(4) *Thermo-Penetration*, or the heating of the diseased tissue to a higher or lower degree, by means of a bipolar current of high frequency, relatively low tension and relatively high amperage. The heating of the diseased mass may be carried to the point of tissue coagulation, diathermy (Nagelschmidt), and electro-coagulation (Doyen), being types of this method; or only such a degree of temperature may be employed as will render the tissues more radio-sensitive, de Keating-Hart's "thermo-radiotherapy" being a type of the latter.

(5) *Fulguration*, or the application, *to the area from which all macroscopic evidence of malignity has been removed*, of a monopolar current of high frequency, high tension, relatively low amperage, with a cooled long spark—"cold lightning," as some critics have called it. This is the de Keating-Hart method. The purpose of this sparking is to modify the local trophism in such a way that any remaining cancer cells, being badly nourished, will tend to retrograde, the probability of recurrence being thus lessened. The action is not at all dependent upon the heat effects of the spark; the important factor, being, rather, the sedation of the cancer cells. By centering the electrode upon a given area, instead of keeping it in constant motion, as insisted upon by de Keating-Hart, the application may be carried to the point of the immediate destruction of tissue by heat, but this is distinctly not fulguration, as the term was employed by Pozzi and accepted by de Keating-Hart.

THE VARIOUS METHODS TO WHICH THE TERM "FULGURATION" HAS BEEN APPLIED.

Alto-frequent Cytolysis, Alto-frequent Scintillation, Effleuvation, Etc. (Rivière.)

It is generally conceded, I believe, that Rivière, of Paris, was the first to employ the high-frequency discharge with a current of sufficient energy to destroy living tissue. His method of treating malignant tumors by high-frequency sparking and effleuves, to which, he declares, the term "fulguration" was subsequently applied, was first described by Rivière¹ in 1900. His conclusions at that time were that "high frequency currents appear to cure small facial epitheliomata and to exercise, in certain cases, a beneficial influence on the evolution of some malignant tumors. *They first produce a thermo-electrical-chemical*

¹Rivière, J. A. Action of High Frequency Currents and of the Effleuves of Oudin's Resonator on Certain Malignant Tumors and on Tuberculosis. First International Congress of Medical Electrology and Radiology, Paris, 1900.

action, the effect of which is to eliminate neoplastic tissues, and, if we admit the parasitic theory, to destroy micro-organisms and their toxins; and, in the second place, they produce a tropho-neurotic curative action, which brings back the vital processes to the normal state.

"It could not be a contemplation to employ the thermo-electrical-chemical action for the elimination of large tumors, for which excision is the elective treatment, but the surgical operation should be followed by the preventive and curative treatment in recurrent cases.

"High-frequency currents, and, more especially, the monopolar effleuves of Oudin's resonator, seem to exercise this action by modifying the vitality of the new regions contaminated by the surgeon's knife during the operation, after having drained and disinfected them. This special mode of applying electricity seems at the present time one of the only therapeutic methods to be tried in cases of inoperable tumors."

Rivière reviewed the subject in 1909,² asserting that since 1900 he had maintained that "every operation for malignant growths should be immediately followed by the application of high-frequency sparks and effleuves, in order to avoid contamination of the open surgical wound and to prevent recurrence." He declared that by means of different electrodes he could pass from the very finest shower of sparks (effleuve) to fat, short (4 to 5 centimeters) sparks, and even to sparks and effleuves of from 5 to 15 centimeters in length. He insisted that de Keating-Hart added nothing to the Rivière method except the "useless spraying, or blowing, of air" through the electrode. Rivière did not agree that the high voltage claimed for the de Keating-Hart method was correct, but that on the contrary the amperage of the latter method is high. For these various reasons it was maintained that the two methods were exactly alike, except for the current of air to which reference has been made.

The correctness of these statements may be judged from the appended description of the de Keating-Hart method.

"Destructive Fulguration."

The term "destructive fulguration" is sometimes applied to the ordinary high-frequency electro-cauterization employed by many surgeons and electro-theraputists in the treatment of benign and malignant neoplasms. In this method a bipolar current, with a short spark, is utilized for "burning down" the growth. With a special apparatus a monopolar current, with long spark, as described by Rivière, may be used. The application, with various machines, of the high-frequency current, with short spark, is the method most frequently referred to as fulguration, and which is most commonly confounded with the fulguration of de Keating-Hart. It is also designated as "electro-carbonization."

The danger of such confusion of terms may be readily understood when it is recalled that the "burning down" of neoplasms is distinctly

²Rivière. Alto-frequent Cytolysis of Cancer. *Journal of Advanced Therapeutics*, July, August and September, 1909, pp. 337, 380 and 433, respectively.

harmful unless the destruction is complete of both macroscopic and microscopic malignant tissue. Careful observations have led to the conclusion that cancer cells at a distance from the area cauterized may be stimulated by the action of the short spark. As Rivi re himself has pointed out, this method cannot be employed for the destruction of large tumors.

Oscillatory Desiccation (Clark).

According to Clark,³ heat effects range in degree from hyperemia to burning, and somewhere between these two extremes there is a point, the effect of which is more than hyperemia and less than burning, which may be called the desiccation point. His method of treating neoplasms consists in the production, the control and sustaining of heat sufficient to cause the rapid dehydrating of the part treated, sterilizing and converting it into an inert mass. This is accomplished by a specialized, true oscillatory high-frequency current, concentrated to a very fine metal point, and delivered in sparks of great frequency through an air space to the tissue. He employs a static machine with a large output (3 to 6 milliamperes).

This method is often referred to as fulguration. Fulguration, "as practiced at home and abroad for several years," according to Clark, "is not desiccation, the thermic degree being too high, and the impact against the tissue too severe." He doubtless refers in this statement to the so-called "destructive fulguration."

Thermo-penetration (d'Arsonval).

In 1896 d'Arsonval demonstrated the power of the high-frequency current to cause a decided rise of temperature in tissues interposed between two electrodes. This property of thermo-penetration has been variously utilized by different investigators. By some, notably de Keating-Hart, it has been employed for the purpose of heating the tissues with a view to rendering them more radio-sensitive; by others (Nagelschmidt and Doyen), it has been used as a means of destruction of neoplasms.

Diathermy, or Transthermy (Nagelschmidt).

In 1907 Nagelschmidt, in Berlin, von Brendt, Preeps, and Zeyneck, in Vienna, and de Kraft, in New York, experimented independently with the thermo-penetrative power of the high-frequency current. Since that time this method has been employed by surgeons in different centers, generally under the name diathermy, applied by Nagelschmidt. The apparatus employed permits the elevation of the temperature of the deep tissues to any required extent, the tumor being destroyed by the coagulation of the tissues. This is merely a thermic means of destruction, having no effect whatever upon the trophic centers.

³Clark, William L. Oscillatory Desiccation in the Treatment of Accessible Malignant Growths and Minor Surgical Conditions: A New Electrical Effect. *Journal Advanced Therapeutics*, 1911, xxii, 169. Also, A Preliminary Report Upon the Destruction of Surface and Cavity Neoplasms by Desiccation. *New York Medical Journal*, 1911, xciii, 1131.

Nagelschmidt,⁴ in a lecture on diathermy and electro-coagulation, delivered before the Electro-Therapeutic Society of London, called attention to the fact that, in passing a high-frequency current through a patient a rise of temperature, which is easily shown by a thermometer, is noted, this rise being largely proportional to the amperage. The greater the amperage, the greater the heating. Inasmuch as the ordinary high-frequency machines are of relatively high tension and low amperage, and inasmuch as diathermy calls for high amperage and relatively low tension, or voltage, Nagelschmidt employed a special apparatus of high amperage and relatively low voltage. This machine has a range of from zero to $2\frac{1}{2}$ amperes.

The current may be applied merely to the extent of heating the tissues, as employed in the treatment of rheumatism, sciatica, etc., or it may be carried to a sufficient extent to cause tissue coagulation, as employed in the destruction of accessible malignant or benign growths, removal of tonsils and adenoids, etc. In the treatment of cancer Nagelschmidt coagulates a layer, removes it, then coagulates another layer, and so on, until the entire mass is removed.

Electro-Coagulation (Doyen).

Doyen, after experimenting to determine the thermal deathpoint of cells, concluded that cancer cells are destroyed by a temperature of 122-131 degrees F. (50-55 degrees C.). Normal cells were found to resist up to 140 degrees F. (60 degrees C.). He employed the high-frequency current for the production of the thermic death of cancer cells, devising for the purpose a special apparatus, with a range of from 10 to 15 amperes. This machine is much more powerful than that used by Nagelschmidt, being capable of the complete coagulation of a large mass at one operation. The cell destruction in this method is the result of tissue coagulation, just as is the case with diathermy.

With the Doyen apparatus at the New York Skin and Cancer Hospital, used for both electro-coagulation (Doyen) and diathermy (Nagelschmidt), it is possible to coagulate tissues to a depth of 5 to 8 centimeters in from one to two minutes. The apparatus produces a current of about three million oscillations per second, and of a strength of from 10 to 15 amperes. The active electrode is placed directly in contact with the tissue, thereby suppressing all sparks.

Bipolar Voltaization (Doyen).

When the electrode is held away from the part being treated, and the sparks are allowed to play upon the area, a superficial carbonization takes place, the underlying tissues being coagulated as when the electrode is placed directly in contact with the part, though not to the same depth. To this method Doyen applied the term bipolar voltaization.

⁴Nagelschmidt, F. The Thermal Effects produced by High-frequency Currents and the Therapeutic Uses of Diathermic Treatment. *Proceedings Royal Society of Medicine*, London, 1910-1911, IV., Electro-Therapeutic Section, 1-12. Also, *Archives of Roentgen Ray*, September, 1910—The Method of Diathermy in Surgery.

Fulguration (de Keating-Hart).

We come now to a consideration of the method to which the term "fulguration" was first applied, viz., the fulguration of de Keating-Hart. It will be understood that in the following pages "fulguration" applies *only* to this method.

Theoretical Basis of Fulguration.

The premise upon which the de Keating-Hart method of fulguration has been developed is that the *monopolar long spark of high frequency and high tension acts not upon the neoplasm, but upon the soil on which the neoplasm has developed.*

Three groups of facts are relied upon by him to establish the premise:

(1) That sparking, even when used with inadequate surgical operation, gives undeniable results, insufficient, perhaps, but already very definite.

(2) That the tumor is in no way modified in its appearance or in its vitality, from which one may reasonably conclude that it is not the tumor itself, but the condition of its nutrition—that is to say, the environment in which it develops—that is transformed.

(3) That laboratory experiments and clinical observation furnish plausible explanations of the foregoing.

It is not within the scope of this communication to detail the experiments which de Keating-Hart and others have conducted for the purpose of determining the action of fulguration upon malignant neoplasms. These have been fully described in de Keating-Hart's various publications, and in my recent article on the subject.⁵

Method of Application.

Apparatus.—The production of fulguration sparks may be accomplished by means of very differently adjusted apparatus. Static electricity and the city current may be utilized, according to the case. The following list comprises the equipment to which de Keating-Hart gives preference, and which we now employ at the New York Skin and Cancer Hospital:

(1) Electric current: city current, dynamos, or accumulators, etc., may be used.

(2) A table holding the rheostats, amperemeters, etc.

(3) A transformer coil with rapid interrupter, or transformer in the closed magnetic current (alternating current).

(4) A condenser furnished with a spark gap.

(5) Oudin's resonator.

(6) A bellows furnished, according to the case, with a foot-pedal or with a tube of carbonic acid, or an electric pump with disinfected air, the latter being used by us.

(7) Special electrodes of de Keating-Hart.

(8) An operating table of wood or metal. The latter is used at the

⁵William Seaman Bainbridge. The de Keating-Hart Method of Fulguration and Thermo-radiotherapy. *Medical Record*, July 6, and 20, 1912.

New York Skin and Cancer Hospital. When a wooden table is employed it must be grounded in order to prevent burning the patient.

Surgical Technic.—The first step of fulguration is purely surgical. This depends entirely upon the exigencies of the case, and need not be given detailed consideration here. Fulguration is essentially a method of treatment for *operable* cancers. The more complete the removal of diseased tissue, the more certain, according to de Keating-Hart, is the freedom from recurrence. The possibility of complete cure and absolute prevention of recurrence is commensurate with the extent to which eradication may be carried. Where only partial removal of diseased tissue is possible the method of fulguration is palliative rather than curative. In these cases thermo-radiotherapy is advocated.

Electrical Technic.—The electrical technic is simple in its description and delicate in its application. The general rule laid down by de Keating-Hart is as follows: Spark for a long time, using powerful sparks of high frequency and high tension, applying them to the area from which every macroscopic trace of cancer has been removed. It is, then, *under* the cancer, and not *upon* it, that the electrical discharge is applied.

The spark should be white, producing the sensation of a violent shock, its mean length to be from ten to twelve centimeters. An important detail is to utilize the spark at its maximum length. The electrode should be kept in constant motion, and should be regularly passed over the surface being treated. The reason for this is twofold: (1) In order to avoid carbonization of the points at which the sparks strike the tissue; (2) in order to equalize the dosage, save at suspected points where one must work energetically.

The dosage or the duration of the application of the spark upon the given point cannot be established in other than an empirical manner. It is not difficult to comprehend the reason for this, when one realizes that no two apparatus are exactly alike, and that in the same apparatus there may be great variations in the primary current, the distance of the spark-gap, and the conductibility of the air which surrounds it, all of which bear an influence, as does likewise the insulation of the patient. Under such conditions the electrical properties of the spark are subject to enormous variation. As a general rule, however one may advise "ten minutes of fulguration for an area of ten square centimeters." This is near enough for ordinary purposes in the majority of cases and with the usual apparatus.

Another guide in the matter of duration is the change in the color of the tissues being fulgurated. All tissues take on a slightly darker tinge, not from destruction, but from the deposit of small blood-clots produced at the surface through contact with the spark. This change of color varies with the tissue involved. While the muscles take on the tinge of smoked meat the bones become slightly yellow. In reality these appearances are apt to be deceptive, depending upon the manner in which the sparking is carried out, and upon the thickness of the sanguinolent fluid through which it passes. As a rule, bones should not

be fulgurated as long as the muscles, or the vessels as long as the tendons.

The two main points to be emphasized are: (1) Sufficient removal of the diseased tissue; (2) powerful sparking of the underlying tissues.

de Keating-Hart's Claims.

The employment of the high-frequency short spark (from 1 to 4 centimeters), at a relatively low tension, produces the effect of cellular stimulation; it provokes a rapid cicatrization of wounds, and exerts a remarkable action upon torpid ulcers. On the other hand, the high tension spark, of a minimum length of eight centimeters, applied for a sufficiently long period of time in proportion to the surface fulgurated, retards cicatrization and transforms a given area into a torpid wound. The wound fills up, but the surrounding healthy tissue contracts. There is, according to de Keating-Hart, a natural autoplasty, not a cicatrization. He considered that the same trophic phenomenon that prevented the reformation of healthy epidermis after fulguration, retarded or suppressed the propagation of cancer *in situ*. The microscopic cancer cell, not the macroscopic growth, is attacked indirectly and destroyed by this method.

It is claimed by de Keating-Hart that all kinds of cancer have given good results under fulguration. In very advanced cases, he says, important palliative effects, such as the suppression of pain and hemorrhage, cicatrization, increase of strength, prolongation of life, have been noted in more than 70 per cent. of the tumors treated by the method. Cancer of the breast has given him 39.5 per cent. cures. Cancers of the buccal mucosa have given 83 per cent. of freedom from recurrence for periods varying from 7½ months to 2 years. He reports 89 per cent. of successes, for a mean duration of 16 months, in inoperable sarcomas treated by means of fulguration.

Apparent Results.

The nature of the method, and its combination with radical surgical procedure, tend to make one cautious in accepting the results as more than apparent cures until a longer time has elapsed and a larger number of observations published. Whether apparent or real, the reported cures and the cases of seemingly great amelioration of symptoms and prolongation of life have led us to believe the method worthy of an exhaustive trial. We have accordingly installed a de Keating-Hart fulguration apparatus at the New York Skin and Cancer Hospital, where, since last November, we have been treating cases by this method. A number of cases which were seemingly far beyond hope of improvement by any other known means have been markedly benefited. It is manifestly too early to say what the ultimate outcome in these or any other cases will be, or to give more than a preliminary statement concerning the work.⁶

⁶Lantern-slide pictures of some of the cases treated by de Keating-Hart were shown. Two patients, who live near Richmond, and who have been under treatment at the New York Skin and Cancer Hospital, were presented.

Thermo-Radiotherapy.

Thermo-radiotherapy is a method of thermo-penetration—a heating of the diseased tissue, with the addition of a cooling of the skin—the purpose being to render the tissues to be treated more sensitive to the x-rays.

The method is based upon the hypothesis that, other things being equal, the radio-sensitiveness of tissues depends upon their temperature. In other words, the higher the temperature (between normal vital limits), the greater the destructive power of radiation upon them.

Elaborating this idea, de Keating-Hart has formulated the method to which he applied the term thermo-radiotherapy. The heating of the tissues is accomplished in the following ways:

(1) In the case of tumors with abundant blood supply, such as sarcomata, physiological hot serum is injected at 50 degrees C., and in such a quantity as to raise the internal temperature of the neoplasm to about 41 or 42 degrees C.

(2) In case of cancer developed in the natural cavities (rectum, vagina, stomach), irrigations as warm as possible are used during a time varying with the needs of the individual case.

(3) In tumors of woody consistency, that can be heated neither by injection nor irrigation, high-frequency currents are employed either by passing the current through needles thrust into the skin, or through an electrode placed on the skin surface. This method is not new.

In order to obviate the danger of x-ray dermatitis in the tissues rendered more radio-sensitive, de Keating-Hart conceived the idea of cooling the organs to be protected. This is accomplished chiefly by two means:

First, the surface is covered with cracked ice wrapped in cotton.

Second, a special apparatus may be employed which cools by blowing the dampened surface with bellows.

Whenever possible, x-rays should be applied during the heating of the cancer, especially when the neoplasm is small and superficial. If the mass is deeply situated, as in uterine cancer, it may retain its warmth long enough for the irradiation to follow immediately after the warming process.

The irradiation must be subjected to the usual rules of radiotherapy. Care must be exercised to prevent auto-intoxication from too rapid cytolysis.

The method is being tested at the New York Skin and Cancer Hospital in a number of cases,⁷ in some of which there has been marked relief of pain. It is entirely too early, however, to predict ultimate findings; this communication is, therefore, to be considered as a purely preliminary statement.

⁷Lantern-slide pictures of patients treated by this method were presented, showing apparently beneficial results.

DIATHERMY (NAGELSCHMIDT) AND ELECTRO-COAGULATION (DOYEN).*

BY WORTHINGTON SEATON RUSSELL, M.D.,

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Electro-coagulation is a term that has been employed by Doyen, of Paris, to designate a method in which currents of high frequency are used for destroying neoplasms by coagulation.

Nagelschmidt uses the name diathermy to indicate the same process, and also applies it to a method in which an elevation of temperature is produced in the tissues without any destructive effect.

That currents of high frequency produce an increased temperature has been known since d'Arsonval, in 1896, showed that if the current be allowed to pass through the body there follows a decided rise of temperature in the tissue interposed between the electrodes. It remained, however, for Doyen, Nagelschmidt and other investigators to utilize this heat property in the treatment of quite a variety of diseased conditions.

Doyen had conducted a series of experiments to determine the thermal death-point of various cells, and as a result, advanced the opinion that cancer cells are much less resistant to heat than are the normal cells. By employing very sensitive thermometers, and after a number of corroborative tests, he reached the conclusion that cancer cells are destroyed by a temperature of between 50° and 55° C. (122°-131° F.), while normal cells are resistant up to 60° C. (140° F.).

This claim, in the opinion of Doyen, having been established, an endeavor was made by him to find that form of heat that would meet the necessary requirement of being able to penetrate the deep tissue and at the same time to destroy the cancer cells lying therein. Hot air, superheated steam and hot water were employed, but while these agents acted most energetically upon the superficial structures, there was absolutely no effect beyond a depth of 4 to 5 millimeters, and, consequently, the use of them was abandoned.

About this time, 1907, Pozzi announced to the Academy of Medicine the use of sparks of high frequency in the treatment of superficial cancer, whereupon Doyen began the employment of this modality.

He began to study the action and effect upon cancer in deep tissues, and finally claimed that the heat produced by currents of sufficient

*Read at the annual meeting of the American Electro-Therapeutic Association, Richmond, Va., Sept. 4, 1912.

strength causes a coagulation of the tissue and a destruction of cancer cells, even at a considerable depth, without a destruction of the normal cells at the same depth. The best results were obtained by placing the patient in contact with a metallic table connected with one extremity of the high frequency apparatus, while the other extremity was connected with the active electrode placed in an insulating handle. Later, the technic was modified, the patient being insulated in a thick rubber pad. The active electrode may be placed directly in contact with the tissue, thereby suppressing all sparks, designated by Doyen as electro-coagulation, or it may be held a distance from the part under treatment, thus allowing a shower of *very short sparks* to play upon the area under the electrode. This method is termed bipolar voltaization by Doyen.

The tetanic contraction of the muscles was so violent, especially when the sparks were employed, that Doyen was obliged to have constructed an apparatus that would produce a current of higher frequency than that usually employed.

A short description of the apparatus used by Doyen, and the similar one imported for test by the Research Committee of the New York Skin and Cancer Hospital, might be of some interest. It consists of a portable stand which contains rheostats, ammeter, fuses, switches, etc., from which lead the wires—one pair to a small motor and the other pair, which conducts the alternating current, to a transformer. A rolling table supports a Ferrié sparking device, composed of a large toothed wheel that is made to revolve very rapidly between two fixed copper plates connected to the source of high frequency and to a d'Arsonval condenser. The sparks pass between the copper plates and the revolving teeth of the wheel. The number of revolutions of the wheel can be regulated from the switchboard, thus increasing or diminishing the number of sparks at will. A solenoid is placed in the circuit, and with a milliamperemeter to indicate the amount of current passing through the patient, completes the outfit. Two wires lead from the solenoid, one passing to a large metallic electrode placed upon the abdomen of the patient, who lies insulated in a thick rubber pad, while the second wire passes to the active electrode.

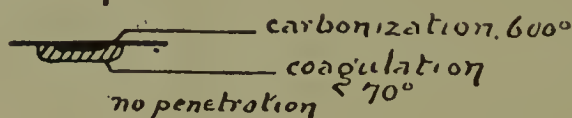
The apparatus produces a current of about three million oscillations per second, and of a strength of from 10 to 15 amperes. If a sheet of foil be placed in the interior of the solenoid, and in the plane of one of the coils, it will be instantly melted. Employing an apparatus as described, and with the proper technic, it is possible to coagulate tissue to a depth of 5 to 8 centimeters in from one to two minutes, using a circular electrode 3 centimeters in diameter.

The electrodes vary in shape and size, and must be carefully selected for each case. Discs of different diameters are employed upon flat surfaces, as skin and mucous membrane, cylindric forms of different size for use in deep parts, and olive-shaped bodies for treating in cavities, semi-insulated in some instances for use in special situations, as rectum, in which it is necessary to localize the action without affecting the surrounding tissue.

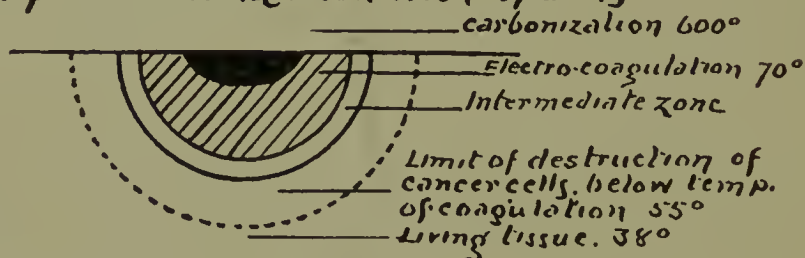
The effect produced by placing the electrode in contact with the tissue (electro-coagulation) differs very decidedly from that obtained by allowing sparks to pass to the part (bipolar voltaization). In the first instance there follows a coagulation of the tissue to a variable depth, depending upon the duration of the application. The temperature within the coagulated zone reaches to from 65° to 70° C. (149°-158° F.), while beyond is an area 10 to 15 millimeters thick, in which there is decreasing temperature from the line of coagulation to the limit of unheated portion of from 65° to 38° C. (149°-100.4° F.). If, on the other hand, the method of bipolar voltaization be employed, there is a superficial carbonization in addition to a coagulation in the underlying tissue; this coagulation, however, does not reach the depth produced by electro-coagulation. The temperature is as high as 500° to 600° C. on the surface of the carbonized area.

EFFECTS PRODUCED ON A PIECE OF MEAT IN ONE MINUTE BY DIFFERENT METHODS.*

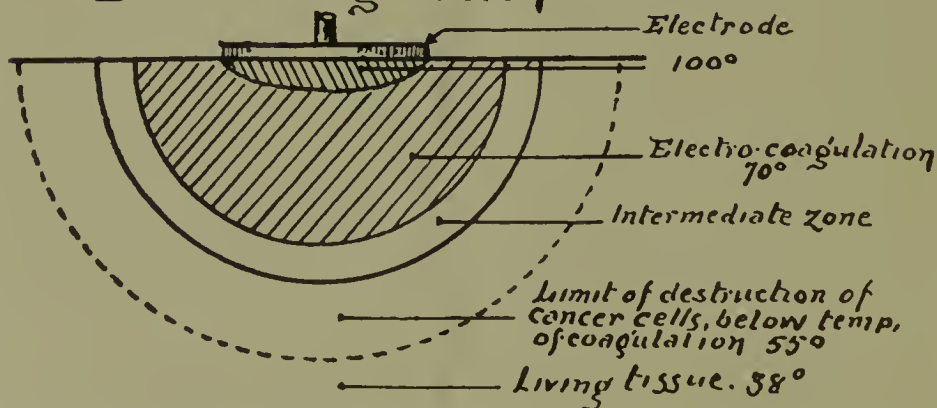
Hot Air



Bi-polar Voltaization with sparks



Electro-coagulation



Great judgment must be exercised in employing the amount of current proportional to the surface of the electrode. If the current is too

*Doyen, E., *Traité de Thérapeutique Chirurgicale et de Technique Opératoire*, 1910.

strong or the electrode too small for the strength of current, there will follow a very rapid rise of temperature, producing a desiccation of the tissue with carbonization, without coagulation in the deeper parts, while a feeble current or a large electrode will fail to produce any coagulation.

Electro-coagulation is used to destroy the neoplasms of the skin and of the mucous orifices. The technic with the proper apparatus is simple: place the indifferent electrode in contact with the skin of the abdomen after the patient has been placed in the rubber pad. The active electrode, equal in diameter to the size of the lesion, is placed in contact with it and the current allowed to pass for from 20 to 60 seconds, which usually suffices to cause a coagulation of the cancerous mass. During the operation, an assistant keeps the indifferent electrode wet by directing a stream of water upon it. A second application at another time may be necessary if there remains any portion of undestroyed cancer. The slough produced separates in from 10 to 15 days, leaving a granulating surface. Very short sparks may be employed, but only when the lesion is quite superficial.

In treating cancer that has invaded such cavities as the maxillary sinus, in which the surface is uneven, it is impossible to avoid a certain degree of sparking; but this may be reduced to the minimum by employing the olive or cylindric electrode, which easily passes into the depressions of the part. The same technic is carried out in the treatment of cancer of the buccal wall, tongue, pharynx, larynx, and of the upper portion of the esophagus. The amount of edema following treatment of neoplasms of the buccal cavity is often so extensive as to necessitate tracheotomy.

Extreme care must be taken while treating in the neighborhood of important vessels, for fear of destroying them, although Doyen claims that the circulating blood keeps the vessels sufficiently cool to prevent the coagulation of their contents. The method cannot be employed in treating cancer of the neck in the immediate vicinity of the pneumogastric nerve, for fear of a fatal result, nor can it be employed in cancer of the abdominal viscera.

In cancer of the vagina, neck of the uterus and rectum, the technic to be followed differs in no particular from that already described, except that wooden specula are employed for dilating the respective canals in place of the usual metallic instruments.

In cases inaccessible to the electrode, as cancer of the bladder, resort is made to surgery in order that the affected part may be reached by the current.

There is considerable lymphorrhea following the application of the current, which may last for some days, and which is often of such a degree as to make necessary the use of saline injections and enemata. This outflow of fluid is deemed to be beneficial, as it prevents infection and serves to flush out the tissue, thus removing cancer cells, bacteria and their toxins. Very little pain follows; occasionally a secondary hemorrhage may occur, due to the dislodgment of a clot.

The success of electro-coagulation depends not only upon correct

technic, but upon its employment before there is an involvement of the neighboring glands or viscera.

The advantages, as summed up by Nagelschmidt,* are as follows: "Electro-coagulation can be used in those tissues inaccessible to the knife; it destroys bacteria and their toxins; it is hemostatic; it favors elimination of cancer cells in the neighborhood, because of the lymphorrhea; it prevents dissemination of cancer cells during the operation for the lymph, and blood vessels are coagulated; finally, it is not specific, and results depend upon correct technic."

The reports coming from abroad of the results obtained by the use of electro-coagulation seemed to be so encouraging that Dr. William Seaman Bainbridge, Surgeon to the New York Skin and Cancer Hospital, during several trips abroad made an investigation of the method. The outcome has been the installation at the hospital of the apparatus as employed by Doyen.

During the past summer the writer, while on a trip abroad, was invited by Doyen to inspect his hospital at Paris. Doyen's collaborator, Dr. Bouchon, devoted much time to giving a demonstration of this method. The conditions treated were epithelioma of the tongue, carcinoma of the body and cervix of the uterus and lympho-sarcoma of the thigh. A short description of the technic might prove of interest. The epithelioma of the tongue, in an adult male, was extensive, involving nearly half of the organ and extending far back to the base. The tongue was drawn forward by means of several silk ligatures passed through it, and the buccal wall was kept away from the field of operation by means of Doyen's wooden retractors, made especially for this purpose. The semi-insulated electrodes were used in order to limit the action to the area, and a current of 2000 ma. was allowed to pass. In from 2 to 3 minutes the temperature of the part had reached the necessary degree of about 53° C., and the electrode was removed. The coagulated mass had a grayish color, and was firm and decidedly hot to the examining finger.

Dr. Bouchon presented the case of lympho-sarcoma of the thigh for the purpose of demonstrating that, when properly used, the method is practically painless. The patient, a young man, submitted to the treatment without an anesthetic, either general or local, and appeared to feel no sensation other than that of heat, unless the skin was touched, and then, and then only, did he flinch. The treatment was continued for about 5 minutes, one ampere of current being used.

In simple diathermy, two electrodes of large size are employed, and so placed on the surface of the body that the current passes through the part under treatment. Contact must be perfect, otherwise there may be sparking and consequent burning. The intensity of the current and the time of contact is not limited, since the sole object is the heating of the tissue without injury.

The passage of the current through the body produces not only a

*Travaux de la Deuxième Conférence Internationale pour l'Etude du Cancer, Paris, 1910.

local rise of temperature, but a general increase as well, accompanied by more or less diaphoresis.

Nagelschmidt reports a number of cases of Bright's disease treated by diathermy. He uses large electrodes, pressed as near the kidney as possible, and passes a current of 1500 to 2000 ma. for from 5 to 60 minutes daily for about six weeks. After the treatment has been discontinued, he notes a disappearance of the edema and a diminution in the amount of albumin. Benefit follows the use of the method in the treatment of cardiac disease, with dropsy, bronchitis, broncho-pneumonia, lumbago, joint affections, as acute gout, rheumatism and gonorrheal rheumatism.

Dr. Bainbridge has discussed the employment of diathermy for the heating of cancerous tissue in inoperable cases, in order to render the tissues more sensitive to the action of the x-ray. This claim has been made by de Keating-Hart, and the method is called by him thermoradiotherapy.

During the past winter a large number of cases were treated by the methods herein described at the New York Skin and Cancer Hospital. It is too early to judge of permanent results, but the different methods are being used on a series of cases, which are being carefully watched by the specialists connected with the Research Department, and as soon as a sufficient length of time has elapsed to warrant a definite conclusion a report will be published.

(Exhibition of lantern slides.)

